Diode Array NIR instrument to analyse fresh forages on a harvest machine

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During the 1998 harvest, a diode array instrument (Perten DA7000) has been installed on a maize silage harvest machine. The same instrument has been used to analyse the maize grain samples directly through the plastic bags used to dry the samples. The dry matter content determined by the oven classical method has been correlated with the spectra and the equations give respectively residuals calibration errors 1.04% and 0.47% for the fresh forage and the grain.

Keywords: near infrared spectroscopy, NIR, diode array, maize, breeding, dry matter.

Introduction

The breeding companies have thousands of experimental plots to harvest each year in many locations. In a particular research centre like the one of Limagrain Genetics in Arras (France), it is not uncommon to reach 10000 experimental plots of hybrid silage maize. These plots must be harvested in a very short period of time. The total weight of the fresh material collected on each plot (2 lines x 5 metres) is automatically recorded. A 500-800 gr subsample is automatically taken on the harvester. For maize grain plots, a combine is used and the procedure is the same. The bags (forage or grains) are then transferred as soon as possible to the drying station, weighed, dried and weighed again to give the dry matter content of each plot. Heavy equipment (ovens) and time consuming treatments entail high costs. In an attempt to reduce them the company thought to use a NIRS instrument directly on the harvest machine to measure the water content.

Material and methods

During the 98 harvest, CRAGx installed a post dispersive diode array instrument (Perten DA7000) on the Limagrain's harvest machine in Arras. The instrument was placed above the rubber belt which dumps the silage on the ground after weighing. Figures 1 to 4 shows the harvester and the place where the instrument and the PC were attached. The regular PC was fixed on a car air tube to absorb shocks and vibrations. Thanks to the high scanning speed of the instrument (1 spectrum/sec), between 10 and 15 replicates have been recorded for each plot while the belt downloaded the matter on the ground after the weighing.

Concerning wet grain analysis at harvest, it was rather difficult to properly install the NIR instrument on the combine due to the configuration and the lack of space. Therefore, the same instrument was installed in the drying station. The maize grain samples were analysed in 4 replicates directly through the micro-perforated plastic bags used to dry the samples. The PLS calibrations were achieved with the Foss Infrasoft International package using a first derivative (D1,1,1) treatment on the averaged spectra (500-1700 by steps of 5 nm).

Results and discussion

The DA7000 is characterised by very low noise values even with an acquisition time of 1 second. The region 400-515 is very noisy and useless. In the 650-1650 nm range, the RMS noise reaches 25 µlog. When 10 scans are averaged or when time is increased to 10 sec, RMS noise is less than 10 µlog within the range 650-1650nm (figures 5, 6 and 7). The bandwidth (fig.8) is similar to the bandwidth of a dispersive monochromator (NIRSystems 6500). Spectral resolution is +/- 5nm which can be a disadvantage for some applications, but seems to be suitable for agricultural products with large absorption bands.

The spectra for fresh silage and wet maize grain and their spread are reported on the following figures 9 and 10.

The peak in the fresh silage data at 1615 nm is due to temperature problem which occurred during the measurements due to a lack of air cooling into the protection box around the instrument. This is the reason why the spectral range has been reduced from 650nm to 1580nm for the calibration process of fresh silage. The grain spectra show quite high noise at the end of the spectra, but no explanation has been found.

Table 1 summarises the calibration results obtained for the determination of dry matter of whole maize plant directly on the harvest machine (DMwp) and the moisture of wet maize grains through the plastic bags (MOIgr).

Conclusions

Regarding the DM of whole maize plant, the breeders are satisfied with a SECV of 1.0 knowing that the repeatability of the oven drying method (subsampling, drying, double weighing) reaches at least 0.5 % (absolute). The NIR predicted values introduced in the analyses of variance for some experimental designs gave very similar results (CV and mean comparisons) to those obtained with the "oven" reference values. The diode array installed in a robust and fast instrument can provide results accurate enough for breeding programs. When the system is adjusted and the software adapted for these conditions, the subsampling and the whole drying process can be omitted.

Table 1.- Statistical results of the NIR regression models

Criteria	units	N	Mean	Min	Max	SEC	R^2c	SECV	R^2v
DMwp	%	774	34.1	23	44	0.99	0.81	1.04	0.79
MOIgr	%	616	31.5	26	38	0.44	0.93	0.47	0.93

Figure 1. The Limagrain's harvester in the field of silage maize plots.

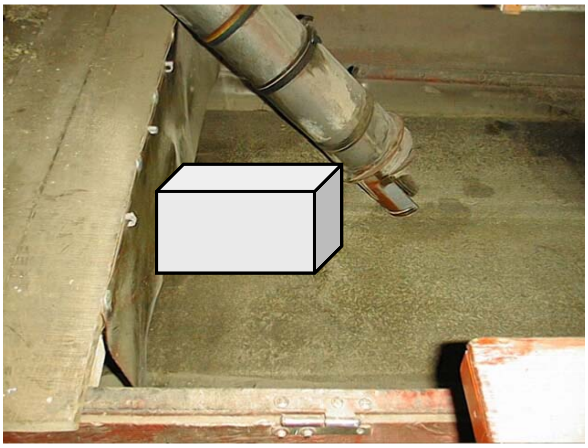


Figure 2. The conveyor belt, the sampling tube and the location of the Perten instrument above the belt.

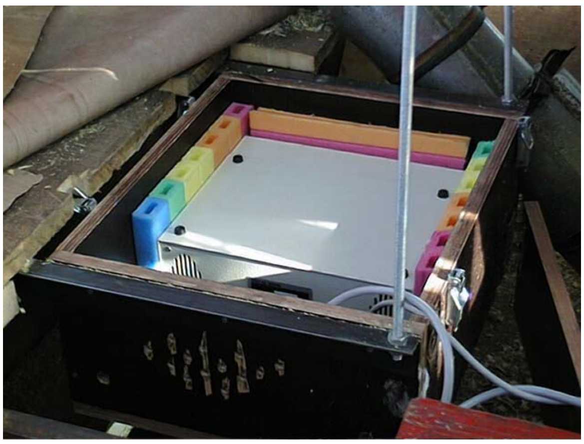
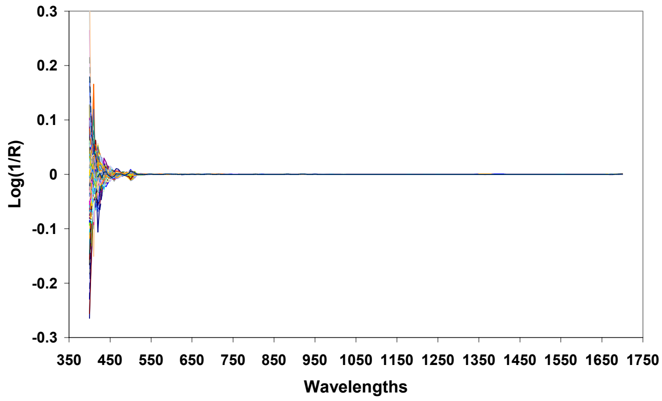


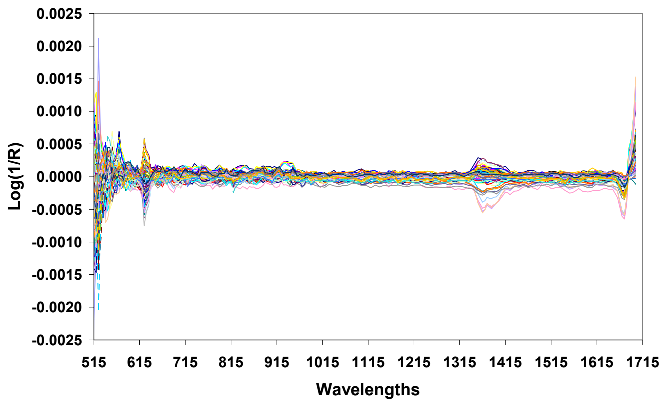
Figure 3. The Perten instrument above the belt and in its protected box.

Figure 4. The PC and the screen placed on the right side of the weighing cabinet.



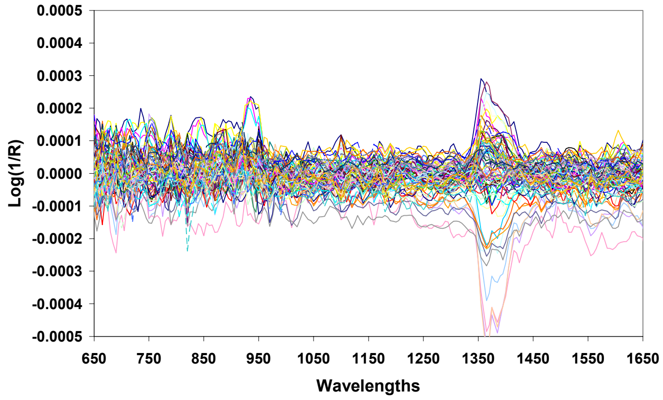
pertennoise.xls graph2

Figure 5. – Noise of the Perten DA7000: acquisition time: 1sec, RMS=10000 μlog; 10 sec, RMS=3200 μlog in the range 400-1700 nm.



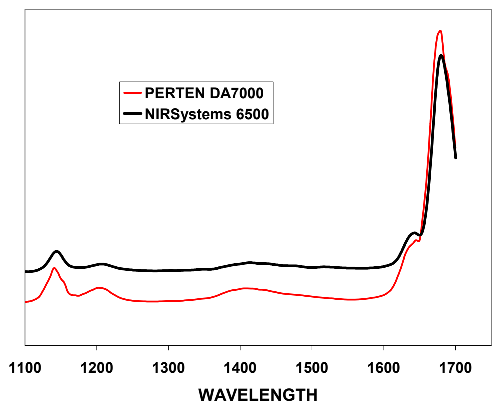
pertennoise.xls graph3

Figure 6. – Noise of the Perten DA7000: acquisition time: 1sec, RMS=90 µlog; 10 sec, RMS=30 µlog in the range 515-1700nm.



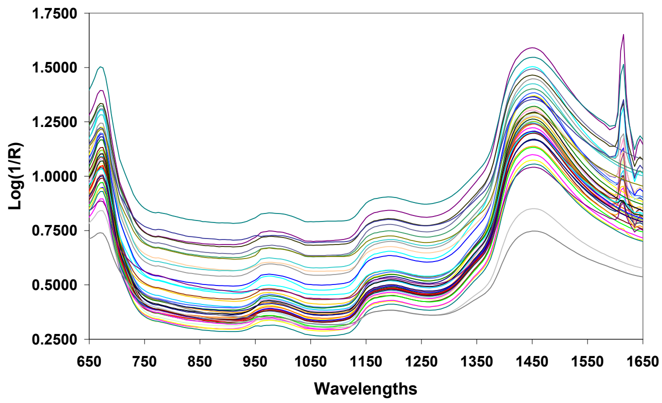
pertennoise.xls graph4

Figure 7. – Noise of the Perten DA7000: acquisition time: 1sec, RMS=25 µlog; 10 sec, RMS=8 µlog in the range 650-1650 nm.



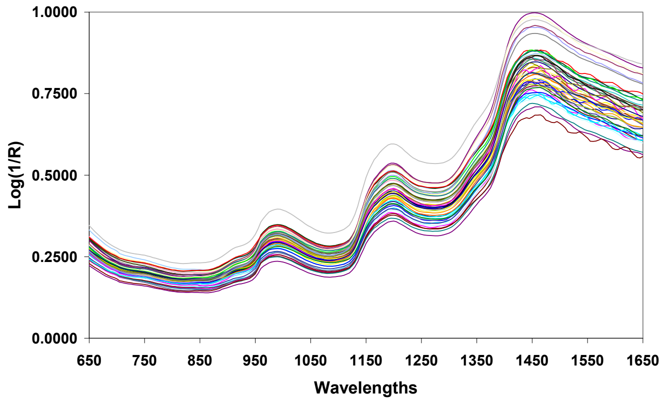
pertenbandwidth.xls graph1

Figure 8. – Bandwidths of the Perten DA7000 and NIRSystems 6500



spl_grap.xls G_maisfrais

Figure 9. – Typical fresh silage maize spectra.



spl_grain.xls, G_Grain

Figure 10. – Typical maize grain spectra.